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Research Memorandum 76-18

# EVALUATION OF THREE BURST-ON-TARGET TRAINERS

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UNIT TRAINING AND EVALUATION SYSTEMS TECHNICAL AREA



U. S. Army

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EVALUATION OF THREE BURST-ON-TARGET TRAINERS

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## INTRODUCTION

### BACKGROUND

The effort addressed in this report is part of a larger one with the objective of developing a model which can be used to predict and to evaluate the effectiveness of training devices. The modeling is particularly aimed at describing how device design, device use, training strategy, and individual ability interact to influence device effectiveness. Standards of effectiveness include both acquisition and transfer of military skills with emphasis placed upon transfer from training to operational settings. The model treats training device effectiveness as a function of: (1) the transfer potential of the device; (2) the learning deficit of the trainees; and (3) the extent to which appropriate training techniques are utilized in the device. Details of the development and rationale of the model are discussed in earlier reports in this series (Wheaton, Rose, Fingerman, Korotkin, and Holding, 1974, 1976; Wheaton, Fingerman, Rose, and Leonard, 1974).

In support of this modeling effort, a field study was conceived which would provide empirical data against which predictions from the model could be evaluated. Based on a review of current Army training devices, Armor School curricula, and interviews with cognizant Army personnel, a group of training devices was selected for intensive examination. It was desired that the selected devices all be applicable to a common training objective in order to facilitate comparisons. Further constraints included local availability, feasibility of use, and ease of instructor and trainee orientation and operation. The decision was to study devices potentially or actually used to train Burst-On-Target (BOT) principles within the context of the Armor Branch of Combat Arms.

This report describes the procedures and results of the BOT field experiment. It evaluates the effectiveness of three training devices for preparing Advanced Individual Training (AIT) personnel to apply BOT techniques with the 3A102B laser devices mounted in the M60A1 tank. Although the results of the field study have direct implications for the model, this report will only marginally touch upon the model or its predictions. This

topic will be covered in later reports in this series. At that time, additional data will be presented bearing on the evaluation of the model.

from pg 4 The devices selected for evaluation in this experiment were: (1) the 17-4 BOT trainer (the "Green Hornet"); (2) a modified version of the 17-4 trainer which was fabricated specifically for this experiment by the Training Aids Department at Fort Knox; and (3) the 17-B4 Conduct-of-Fire Trainer. to page -3- The general plan was to train one group of trainees on each device until a specified level of BOT accuracy was obtained. These groups would then transfer to the M60A1/3A102B laser configuration for a specified number of trials. A fourth group of trainees (controls) would merely practice on the laser device for a fixed number of trials, without respect to level of accuracy obtained.[1] Transfer effectiveness was conceptualized as a composite of the accuracy with which trainees could apply BOT and the time necessary for them to get off their second shot in a BOT engagement. Various other analyses were undertaken and are reported in later sections of this report in order to evaluate potential and actual training effectiveness.

In summary, the purposes of the present experiment were twofold. The primary purpose was to evaluate the relative effectiveness of the three devices for training BOT, as measured by skill in applying BOT on the 3A102B device. The second purpose was to evaluate the overall potential of the three devices for training, including other tasks related to tank gunnery.

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[1] We would like to thank LTC Willis G. Pratt, Chief, U.S. Army Human Research Unit, Fort Knox, Kentucky, for his help in setting up and co-ordinating requirements to perform the research described in this report. We would also like to acknowledge the assistance and cooperation of COL Roderick D. Renick, Commander, First Training Brigade, Fort Knox, and LTC Bruce McConnell of the First Training Brigade, for allowing us to use their personnel in the experiment. Special thanks are due to CPT Ernest Wagner who did all the leg work in setting up the experiment and who was always available to serve as trouble-shooter when problems occurred. Finally, we would like to thank all of the Fort Knox personnel who served as trainers and spotters during the experiment, as well as the drill sergeants who helped manage the orderly flow of trainee personnel.

Outline of the Report

The approach that was taken in the conduct of the experiment is described. Rationale, procedures, selection of subjects and instructors, and experimental controls are discussed in detail. A detailed description of the features of the three training devices and the criterion system is also provided.

from pg 2 The results of the experiment are presented ~~next~~ along with the supporting statistical analyses. The first part of the section presents data on trainee acquisition of BOT skill prior to transfer. Data are reported regarding the average number of trials required to reach proficiency on the three devices, as well as the speed and accuracy with which skill was attained. The second portion of this section discusses the ability of students trained on the alternative devices to transfer their BOT skills to the test situation. Between-round time interval and accuracy data constituted the dependent variables of interest. Finally, a series of analyses are presented which deal with the subjective reactions of both students and instructors to the training devices.

After a detailed discussion of the results, conclusions are drawn regarding the effectiveness of the various devices within the context of the experiment.

APPROACH

*(Burst-on-target)

## OVERVIEW

The immediate purpose of the experiment was to compare the efficacy of three training devices, ~~the 17-4, 17-4 modified, and 17-B4 BOT trainers,~~ for training and transfer to a BOT* task performed on M60A1 tanks equipped with the 3A102B laser device. The general strategy was to train a group of 20 trainees on each device and then to have those trainees perform the BOT criterion task on the "operational equipment." A fourth control group simply practiced the criterion task without benefit of any prior training. The performance of the control group provided a frame of reference against which to compare the absolute levels of performance achieved by the device groups as a result of training. → to page -2-

Various constraints were placed on the training system in an effort to improve the validity of the obtained results. For example, all trainees, including the control group, received the identical preexperiment treatment. No trainee received any instruction or exercise concerning BOT or involving any of the devices, except for a special lecture given the day before the experiment began. This lecture presented the basic principles of BOT as well as conduct-of-fire procedures. Thus, bias due to differential pre-experiment training was minimized. Further control was exercised by insuring that the sequence of events for the different training situations was as similar as possible. This was accomplished by giving all instructors the same preexperiment briefing (see Appendix A). Finally, various counter-balancing procedures were used in the experiment in order to control for possible differential effects due to: 1) differences among instructors on a given device; 2) differences among the four devices used by a given group; 3) time of day for the transfer task; 4) different tank commanders during the criterion task; and 5) differences among the tanks used in the criterion task.

The remaining portions of this section describe the experimental method in detail. Included are descriptions of the three training devices in terms of their physical appearance and functional operation. Description of the "operational equipment," on which control subjects practiced and

onto which trained subjects transferred, is also provided. This is followed by information about the trainees and instructors. Finally, a description of the experimental procedures is presented.

## DESCRIPTIONS OF TRAINING DEVICES

17-4 Burst-on-Target Trainer ("Green Hornet"). The 17-4 trainer used in this study is an altered version of DVC 17-4 Conduct-of-Fire Tank Gunnery Trainer as described in DA pamphlet #310-12(1972), which was fabricated locally at Fort Knox, Kentucky. The device consists of a wooden frame containing a firing switch and a mock fire-safe switch. Mounted directly on the frame is a 27" x 27" painted terrain sketch (the actual sketch being different for each device). An equivalent-sized transparent plastic panel with a circular aperture displaying an acetate reticle is mounted directly in front of the painted terrain sketch. This panel is mounted in horizontal and vertical metal tracks, enabling movement in either direction. Attached to the movable panel, and lying directly behind the terrain sketch, is a metal plate. When the front reticle panel moves, the rear metal plate moves simultaneously. A number of small holes are drilled in the metal plate. When a small light is placed directly on one of these holes from behind, a "burst" appears on the terrain sketch.

In operation, the gunner places the cross hairs of the reticle directly on a designated target in the terrain sketch. Movement of the panel is accomplished through the use of two metal handles on the bottom of the front panel. Trainees actually lift the entire panel in order to properly position the cross hairs on target. As part of the present experiment, "point" targets were painted directly on five targets in each scene. Thus, trainees know precisely where to place the cross hairs, thereby reducing uncertainty about the proper center-of-mass aiming point. Before each trial, the instructor places the rear light on one of the holes in the metal plate. Subsequently, when the trainee presses his trigger to fire his first shot, the instructor simultaneously flips a switch in the rear of the device which activates the light. The trainee then sees a burst displaced from the target for approximately one second. Using this feedback, the trainee then determines a new aiming point and moves the cross hairs to the appropriate position. Since the metal plate and the "burst"

move with the reticle, adjustment of fire is possible. The device provides feedback on the gunner's second-shot accuracy when he presses the trigger switch again and notes where the burst from the second round falls. Training on the 17-4 device was conducted in Ifland Room #1.

17-4 Modified Burst-on-Target Trainer. This device is practically identical to the 17-4 described above, with the following exceptions. First, in the 17-4M the painted terrain sketch is not mounted directly on the frame; the sketch itself is attached to rollers so that the scene can be changed periodically. Also, all scenes are identical, so that each device can display the same targets to all trainees. During the course of the experiment, however, the same fixed scene was used on all devices.[2]

Second, the instructor's switch to light the "burst" is attached to an extension cord instead of being mounted on the back of the device. This enables the instructor to move around to the front of the device in order to monitor and score the trainee's performance more accurately.

Third, since the 17-4M devices are somewhat newer than the 17-4 devices, they are easier to manipulate; there is less friction and the movable panel is somewhat lighter than on the 17-4s. While there are a few other physical differences (e.g., the presence of an "indexing handle" in the 17-4M), they are not relevant to the task studied in the present experiment. The only other difference of potential impact is the psychological fact that one device is called the "old" 17-4, the other the "new, modified" 17-4M device. Training on the 17-4M device was conducted in Quinn Room #2.

17-B4 Conduct-of-Fire Trainer (Wiley). The relevant aspects of the device for the current experiment will be described from the trainees' and instructors' points of view.

The trainee views once of five rear-projected slides depicting tanks at different ranges, in various terrain and orientation, through a regular M32 sight. When required to place the cross hairs of the reticle on the

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[2]A potential problem occurs if the rollers are too loose. In this case the scene tends to warp and diffuses the burst feedback. This diffusion or "ballooning" makes scoring difficult and feedback less meaningful.

appropriate target, he activates a set of power tracking controls physically identical to the traversing and elevating power controls in the M60A1 tank. To position his reticle, he has to depress the palm switches in order to elevate or traverse. (In fact, operation of the controls results in the slide moving in the desired direction.) Depressing the trigger switch activates a small laser inside the device, and illuminates a red rear-projected/slide image (intensity of the dot is not uniform among devices). When firing of the main gun is simulated, burst duration is approximately a tenth of a second. As in the other two devices, trainees perform the BOT adjustment by determining a new aiming point and placing this new point at the appropriate location on the target.

In order to displace the burst to insure a first-round miss, the instructor depresses a "Random" button mounted on the side of the device. The effect of this input is to move the burst from the initial aiming point in an unpredictable fashion. To enable instructors to monitor performance, the trainee's visual display is duplicated on a large repeater display located on the front of the device. Instructors can change slides by simply activating the slide-tray controls on the side of the device.

As previously mentioned, the targets on the 17-4 and 17-4M devices had "point" targets painted directly on the display. Since this was not possible on the 17-B4, precautions were taken to insure that trainees knew precisely where they were to aim each time a new target slide appeared (every 8 trials). The instructor placed the cross hair on the exact point on the target that would be judged a hit and made sure that the trainee understood where he was to aim. During the preexperiment briefing, the instructors agreed on the exact areas on the different slides that would be judged a hit.

It should be pointed out that although the power controls on the 17-B4 and the M60A1 are physically identical, the effect of control manipulations is not the same. The M60A1 controls are acceleration controls: a given deflection of the control handles produces a specific turret velocity (e.g., a $10^{o}$ control deflection translates into a certain angular velocity of the turret). In order to stop turret movement, the gunner must return his controls to a central or "null" position (or, less desirably, release

his palm switches). Furthermore, there is practically no "jerk" when the controls are moved off center; the slightest movement of the controls is sufficient to move the turret. Although precise engineering specifications are not readily available, it appears that the 17-B4 control system is basically a "velocity" control: a given deflection of the control handles produces a specific linear distance (e.g., a $10^{o}$ control deflection translates into a certain number of degrees of movement). In order to stop "turret" movement, the gunner merely stops moving his control handles (or, again less desirably, releases his palm switches). In addition, as opposed to the tank controls, it seems as if the 17-B4 has a larger built-in "jerk" response. There is a large movement threshold in the controls such that the movement of the handles must exceed a specified extent before the display movement commences. Training on the 17-B4 device was conducted in Flint Room #4A.

M60A1 Tank/3A102B Laser. The criterion or transfer task selected for the present study was Burst-on-Target (stationary target), using the 3A102B laser device mounted in the M60A1 tank. This device is an earlier version of the M55 laser device. It is mounted directly in the M-73 machine-gun bracket and is boresighted and zeroed with the gunner's sights and the tank commander's range finder. The major function of the device is to simulate main gun rounds; when the trigger is pressed, a low-power laser is activated. The laser emits a low-power, red pulse (duration $<$ 1/10 second) that represents the burst of a main gun shell. Since the gunner uses the normal optics of the tank, the location of the burst on the target is sensitive to range adjustments by the tank commander: if he ranges "long" (i.e., greater than the 1200 meters at which the device was zeroed), the burst will appear above the target; if he ranges "short", the burst will appear below the target.

The targets used in the present study were 2" x 2" squares, outlined with black (nonreflective) tape and mounted on normal "Scotch-Brite" target boards. These targets simulated a 3.5' x 3.5' square at 1200 meters. When properly focused, the laser burst could fit completely inside the target square.

In operation, the trainee (gunner) places his cross hairs on the center of the target (following a fire command from the instructor). The first burst is displaced above or below the target by a fixed amount. This is accomplished by having the instructor enter a pre-specified and incorrect range on his range finder. The ranges used varied between 1000 and 2000 meters (zeroed at 1200 meters). Following his first round, the trainee attempts to correct his aim and hit the target on his second shot. Hit-miss and inter-shot time interval[3] data were recorded by the instructor. Spotters were provided to assist the instructor in making hit-miss decisions. Control subjects received a total of 320 BOT trials distributed across 2 days and eight 40-trial sessions. Trained subjects transferred to this setting following the procedures described below.

TRAINEES

The experimental and control subjects were 80 11E10 trainees from the third and fourth platoon of A Company, 3rd Battalion, 1st Training Brigade. These trainees were divided into four groups, corresponding to the three training devices and the control condition. To reduce unwanted acquisition or transfer effects due to initial differences among the groups, an effort was made to match the groups along dimensions of potential influence. These dimensions consisted of: (1) Army status (Regular Army or Other); (2) Prior service; (3) GT score; (4) Educational Level (high school and above, 10-12th grade, or below); and (5) End-of-Block scores. Accordingly, trainees were assigned to groups in order to minimize between group differences on the various dimensions.

Unfortunately, performance data from three trainees could not be used. It was discovered after the conclusion of the experiment that two trainees had extensive previous experience in tank gunnery; their scores were not considered comparable to the rest of the population. A third trainee was excused from the transfer task for medical reasons. Since two of these three cases were from the same training group, subjects were randomly eliminated from the other groups to produce a balanced design.

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[3]The laser device has a 3-second recharging interval between rounds; thus, inter-shot interval times might be constrained at the low end.

Thus, analyses were performed with N=18 for each group.

INSTRUCTORS

A total of 16 11E qualified tank commanders served as instructors. These personnel were obtained from the 1st Battalion (5), 2nd Battalion (2), 3rd Battalion (7), and from the Armor School (2). Instructors from the 3rd Battalion were not from A Company, thus insuring that no trainee was familiar with any instructor.

All instructors had previous experience in teaching BOT. All were familiar with the operation of the 17-B4 device and had used that device for training. A smaller number of instructors were familiar with the operation of the 17-4 device. Naturally, none was familiar with the 17-4M device. In order to familiarize instructors with the devices and the experimental procedures, time was set aside for briefings and practice prior to the actual conduct of the experiment. Instructors were not briefed on how to teach BOT; it was assumed that no specific teaching techniques could improve upon their considerable experience in instruction.

PROCEDURE

The 80 trainees were divided into four groups of 20, each group being assigned to either the 17-4, the 17-B4, the 17-4M device or to the M60A1/3A102B control condition. Each group was then further divided into four groups of five trainees, corresponding to the four specific devices used in each training situation. On the first day of training, each group of five trainees reported to a specific training device and a particular instructor. The instructors were given a half hour to brief their trainees on the training device and on BOT principles. During this period, no trainee was allowed to actually operate the device, to fire a shot, or to manipulate the controls.

Following the orientation session, each trainee had a 40-trial session on the device itself, while the other four trainees observed. One of these served as "Loader" and was required to follow the prescribed sequence of fire commands and to make the appropriate responses. After all five trainees completed one session, there was a short break, followed by a second session on the same device. Upon completion of their second session, the group of five trainees moved to a different device and instructor; each

instructor also moved to a new device and a new group of trainees. This schedule was repeated until all trainees had completed training.

Each of the 40 trials within a session consisted of a fire command from the instructor, a shot by the trainee, a Burst-on-Target adjustment by the trainee and a second shot. The detailed sequence of events for a single trial was as follows:

1. The instructor introduced a predetermined burst deflection as designated on his scoresheet. For the 17-4 and 17-4M devices, this was accomplished by moving the lightbulb to one of a series of designated pinholes. On the 17-B4, error was introduced by pressing the "Random" control button. On the 3A102B, it was accomplished by introducing a predetermined range error into the optical system.
2. The instructor issued a three-element fire command (e.g., "Gunner, HEAT, Tank") indicating the appropriate target. For the 17-4, 17-4M and 17-B4 devices, there were five unique targets; each target was used for eight consecutive trials. For the 17-4 and 17-4M devices, the five targets were located at different points on the same basic scene. For the 17-B4, five different slides were projected sequentially.

   After the instructor issued the initial fire command, the trainee acting as Loader operated the "Safety/Fire" switch and said "Up"; the trainee-gunner said "Identified"; and the instructor replied "Fire."
3. The trainee-gunner took initial aim, said "On the way," paused, and fired his first shot. The instructor activated a stopwatch when the trainee fired.
4. The trainee-gunner then performed his BOT adjustment, heard "Up" from the Loader, announced "On the way," paused, and fired his second shot. The instructor stopped his stopwatch when the second shot was fired.
5. Instructors monitored for second-shot hit or miss and announced this to the trainee. The instructor then recorded

the hit-miss and elapsed time information on the scoresheet (see Appendix B).

6. Instructors prepared for the next trial by zeroing the stopwatch and entering the burst deflection for the next trial into the device.

Between trials, instructors were permitted to critique the trainee's performance as they felt appropriate. The entire sequence of events was repeated for a block of 40 trials; elapsed time to complete the 40 trials was approximately 15-20 minutes.

Training ceased for a given trainee when he reached a proficiency criterion of 18 hits out of any 20 consecutive trials (90% proficiency) or when he completed a maximum of 320 trials, whichever came first. The decision to use a proficiency criterion rather than a fixed number of trials was made in order to avoid large individual differences in skill level at the end of training. For any small fixed number of trials some trainees would presumably be very proficient, while others would be relatively poor. At the other extreme, a large fixed number of trials would run into the potential problems associated with overtraining.

Instructors were told to adopt a very strict criterion for determining hit or miss on the trainee's second shot of a BOT engagement. Each target had a small area designated as the center of vulnerability. A hit was scored only if the second-round burst hit this designated area. Following training, trainees filled out a short questionnaire concerning their attitudes about the device (see Appendix C). They also completed this questionnaire following transfer. Instructors provided the same information. However, they completed the questionnaire prior to and immediately after training.

Upon fulfillment of all training requirements, a given trainee was released for the remainder of the day. The criterion (transfer) occurred on the day following the second training day. In order to control for potential effects due to different training-transfer intervals, those trainees who had reached 90% proficiency on the first training day fired a short set of warm-up trials on the second day. Thus, all trainees received their last practice on the devices on the day before they performed

the transfer task.

During transfer all trainees fired two 40-trial sessions on the tank: one session in the morning, the second in the afternoon (on a different tank). Trainees were properly sequenced to eliminate a possible differential influence of time-of-day on the performance of the three groups, as well as an influence due to instructor or tank. Thus, at any point in time, there were two trainees from each group performing on the six tanks. By the end of the transfer schedule, each group was equally represented on each tank. Performance data collected were hit or miss and inter-shot time interval on each trial.

# RESULTS

In presenting the results of the Burst-on-Target field study, emphasis has been placed on those findings which permit an evaluation of the effectiveness of the 17-4, 17-4M, and 17-B4 training devices. Accordingly, the findings have been arranged under three general headings. First, data are presented which describe how trainees in the various device groups acquired skill in applying BOT during the initial or training phase of the study. In examining these learning data the critical issue is the difficulty which trainees experienced in attaining the criterion (90%) level of proficiency. The second set of analyses relates to the primary objective of the study. It addresses the question of how successful trainees in the various groups were in transferring their BOT skills to the test situation--in this case to M60A1 tanks equipped with the 3A102B Laser Conduct-of-Fire device. The third set of analyses and results is supplementary in nature, and has been included to clarify certain aspects of the acquisition and transfer data. Included under this last heading are analyses describing the subjective reactions of both trainees and instructors to the training devices with which they worked.

## ACQUISITION OF BOT SKILL

Trainees in the three training groups continued to practice the BOT task until they reached the 90% accuracy level or until they had received a total of 320 BOT trials. Trainees in the untrained baseline group received a total of 320 BOT trials on the 3A102B configured tanks, without reference to a proficiency standard. Consequently, the first way in which devices could be evaluated was to compare the course of acquisition on the different devices. Three types of data were available for this purpose, including: 1) the proportion of trainees in each group who failed to reach the 90% proficiency level; 2) the average number of BOT trials required by each group to reach criterion; and 3) the course of acquisition for the two performance measures of interest--accuracy and speed.

With respect to the proportion of trainees reaching criterion, the three devices were indistinguishable. All individuals in the training

groups reached the 90% accuracy criterion within the number of trials allotted. Large individual differences were noted, however, in the number of trials required. For example, trials to criterion on the 17-4, 17-4M, and 17-B4 devices ranged from 40 to 209, 92 to 309, and 25 to 226 trials, respectively. In other words, some trainees managed to obtain 18 out of 20 hits (90%) during their very first practice session while other trainees needed as many as six sessions or, as in the case of one individual on the 17-4M, all eight sessions to reach criterion.

The average number of trials to criterion on the 17-4, 17-4M, and the 17-B4 devices were 125.0, 169.4, and 134.1 trials, respectively. An analysis of variance conducted on these data revealed that trainees required significantly different numbers of trials in reaching the criterion on the three training devices ($F = 3.48$, $df = 2,51$; $p$ .05). Trainees on the 17-4M device reached criterion one full session later than those who trained on the other two devices.

The third and final set of acquisition data on which the devices were compared consists of the accuracy and time data obtained during training. However, since trainees required widely different numbers of trials to reach criterion, and because the trials to criterion also differed significantly among devices, it was difficult to find a baseline (e.g., trials) against which to plot the response measures to represent the course of acquisition. To deal with this problem Vincent curves (Kimble, 1961) were constructed. Such curves describe performance level as a function of deciles of practice.

Figure 1 shows percent hits in BOT adjustment of fire as a function of deciles of trials to criterion. Accuracy data are shown for the three training groups as well as for the unpracticed control group.[4] The data clearly indicate increasing levels of proficiency for all four groups. An increase was, of course, required of the training groups inasmuch as the accuracy measure served as the criterion which terminated training. The unpracticed control group also acquired considerable skill, starting

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[4]For this latter group, each student received 320 trials; therefore, each decile equals 32 trials.

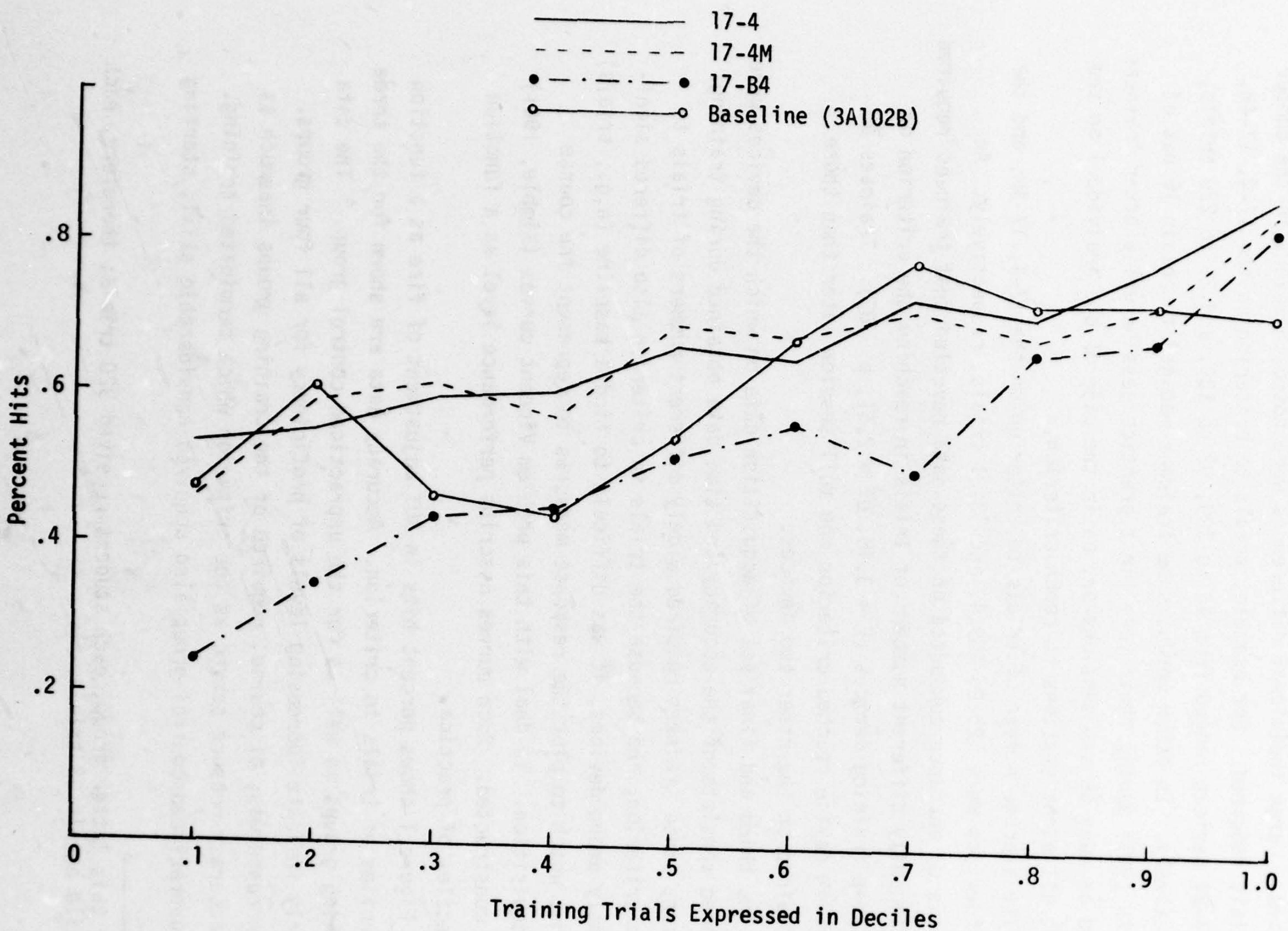


Figure 1. Percent hits during training as a function of stage of practice (Vincent curves).

at 48% hits and leveling off at approximately 72% hits.[5]

Two other features of these data were of interest. First, despite the fact that the 17-4 and 17-4M groups differed substantially in terms of number of trials to criterion, the course of acquisition for accuracy was remarkably similar for these two devices. Both started off with an initial hit rate of approximately 50% and showed a relatively slow rate of acquisition. Second, while the 17-4 and 17-B4 required comparable trials to reach criterion, initial percent hits on the two devices were quite different. Initial accuracy on the 17-B4 was at 24%, and only after trainees in this group were half through training did they reach the 50% hit rate achieved from the outset on the other devices. This result suggests that the 17-B4 was initially more difficult to master than the other devices. The greater difficulty of the 17-B4 device was also suggested by the time acquisition data presented in Figure 2. In this figure the interval between first and second rounds is shown as a function of deciles of practice. Trainees who trained on the 17-B4 started off with an interval of 11.8 seconds, which was cut to 9.6 seconds halfway through training, but which finally rose back up to 10.9 seconds. The other two training devices produced between-round intervals which were far shorter and which remained constant across stages of practice.

Finally, the untrained control students, who were simply instructed to apply BOT as accurately and as rapidly as possible, showed acquisition of speed over practice. While initially requiring 9.7 seconds between rounds, halfway through their regimen they had reduced the interval by approximately two seconds, and eventually required only six seconds between rounds. It is instructive to note that the performance of this baseline group was consistently faster than that of the 17-B4 group. Part of this difference was probably due to the fact that while controls in the two devices were identical in physical appearance, the M60A1 and 17-B4 controls were functionally quite different.

[5]The final spurt to high levels of proficiency by the training groups was an artifact of Vincent curves occasioned by the runs criterion requiring 18 hits in 20 successive trials.

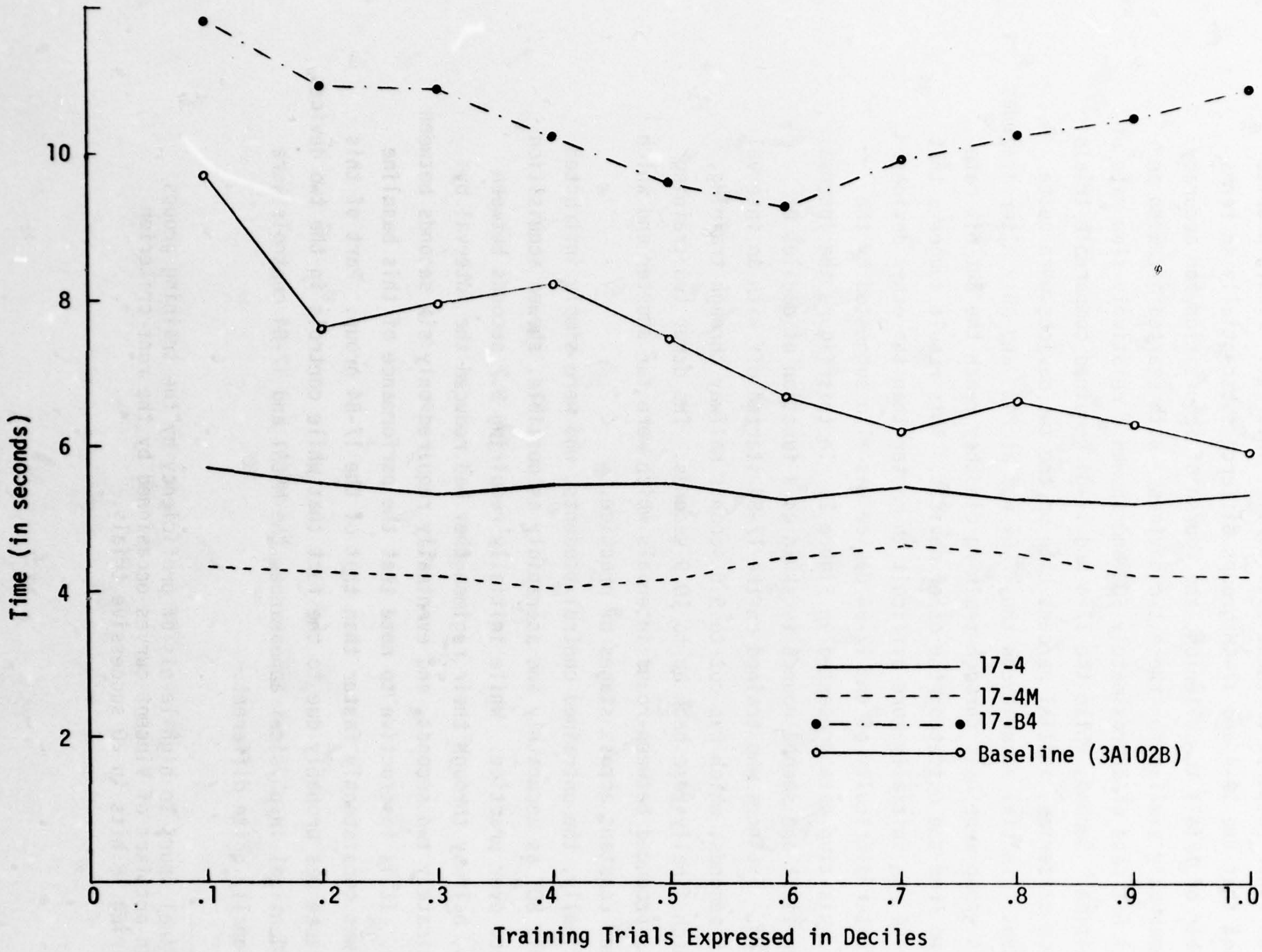


Figure 2. Time between first and second rounds as a function of stage of practice (Vincent curves).

TRANSFER OF BOT SKILL

The issue of primary interest in this study was the ability of trainees trained on the alternative devices to transfer their BOT skills to the test situation. It will be recalled that this situation required trainees to apply BOT as accurately and as rapidly as possible using laser configured tanks as the transfer vehicle.

The first step in analyzing the data obtained from the transfer phase of the study was to determine whether the tanks/tank commanders[6] to which trainees were exposed had an influence on accuracy or speed scores. The data were collected in a manner which made such analysis possible; three trainees from each training device shot their transfer rounds on each of six tanks during a morning (40 trials) and an afternoon (40 trials) session. These data were cast into analyses of variance which treated tanks and trials as the independent variables.

Results of the analyses indicated that the accuracy of trainees during transfer was affected significantly by the tank on which they shot, and that this influence varied over time (e.g., tank by trial interaction in morning, $F = 1.28$; $df = 195, 1872$; $p < .001$). Similarly, the time-between-rounds data were also biased by the tank on which trainees shot and this bias changed over trials (e.g., tank by trial interaction in afternoon, $F = 1.36$; $df = 195, 1872$; $p < .001$). Accordingly, the decision was made to adjust transfer accuracy and speed data to eliminate biases due to tanks. The adjustments were made by computing a mean effect for each tank at each block of 10 trials, and adding or subtracting this effect, as appropriate, to all scores obtained from each tank at each block. Similar adjustments were applied to the acquisition data obtained from the untrained control group of trainees.

Transfer of training was evaluated by casting the adjusted accuracy data into a 4 x 8 x 10 analysis of variance where the independent variables were: the 17-4, 17-4M, 17-B4, and Control groups, eight blocks of trials, and 10 trials within each block. There were 18 trainees within each of the four groups. Complete results of the analysis are presented in Table 1 of Appendix D.

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[6] Tank commanders did not change tanks during the transfer portion of the experiment.

The major finding stemming from analysis of the accuracy data is shown in Figure 3. All groups, including the control trainees, showed significant improvement in accuracy across the 80 transfer trials ($F = 10.43$; $df = 7, 476$; $p < .001$). No significant differences were noted among groups ($F = .08$; $df = 3, 68$; $p > .25$). Considered jointly, trainees initially performed at a 42% hit rate and gradually improved to approximately 60% hits. It should be remembered that this terminal hit rate involved applying BOT on a 2 x 2 inch target at a distance of 60 meters. This would be equivalent to shooting at a three-and-one-half-foot square located at a distance of 1200 meters.

In addition to the full-scale analysis of variance, the accuracy data were also subjected to a series of a priori planned comparisons based on single-degree of freedom F-tests. In these comparisons each training device group was compared with the control group at the first and last block of trials. These comparisons, using one-tailed tests, revealed that upon initial transfer the 48% hit rate of the 17-4M device was superior to the 38% hit rate of the control group ($F = 3.85$; $df = 1,476$; $p < .025$). There was a suggestion that the 17-B4 (hit rate = 46%) was also superior but the difference did not reach conventional levels of significance ($p > .10$). In the last block of transfer trials the 17-4M group applied BOT more accurately than the control group but this finding should not be given a great deal of weight. As shown in Figure 3, the difference appears to be due primarily to a tailing off of the control group during the last block. The general impression provided by all of the analyses, and echoed by the data shown in Figure 3, is that prior training in applying BOT did not have a pronounced effect on BOT accuracy during transfer.

As shown in Figure 4, however, prior training did have a substantial impact on the time between rounds. An analysis of variance was conducted on these data, the detailed results of which are presented in Table 2 of Appendix D. The most salient finding was a significant interaction between groups and blocks of trials ($F = 2.56$; $df = 21, 476$; $p < .001$). The interaction implies, as shown in Figure 4, that the differences among groups changed over the course of the transfer episode. The initial wide spread in performance decreased as practice continued.

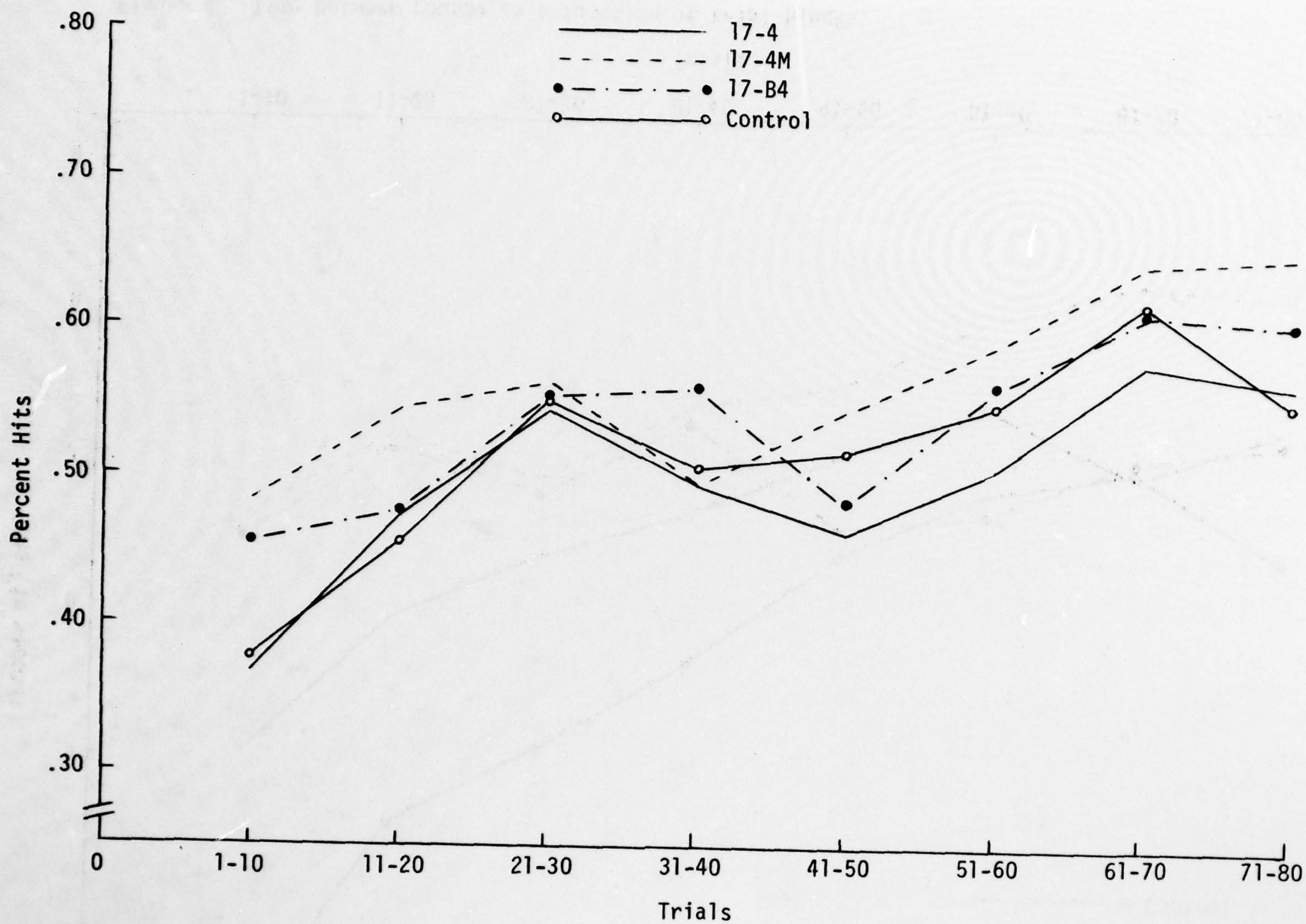


Figure 3. Percent hits in transfer as a function of trial blocks.

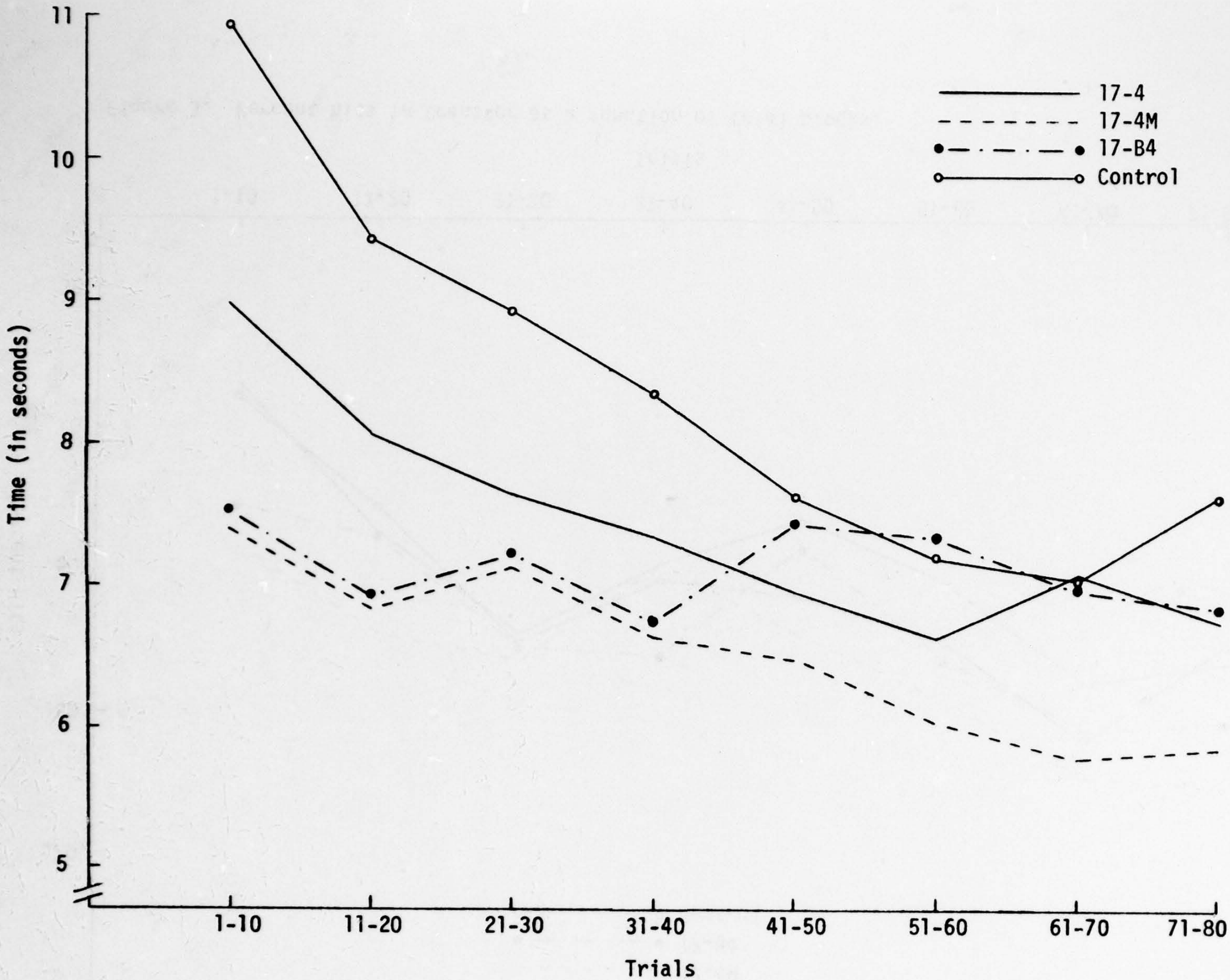


Figure 4. Time between rounds as a function of trial blocks.

Analyses of variance of simple effects (Kirk, 1969) were undertaken to investigate these relationships in more detail. Basically, such analyses permit one to examine differences among groups at each block of trials or, alternatively, differences in performance across blocks for each group. The detailed results of these analyses are presented in Table 3 of Appendix D; only the more salient findings are presented here.

The first finding of interest was that significant differences among training and control groups appeared at each of the first four blocks of trials and disappeared thereafter. Scheffe tests (Hays, 1963) were conducted to get at the nature of the differences. During the initial block of trials, the 17-4, 17-4M, and 17-B4 device groups were each significantly faster than the untrained control group. This finding indicated that positive transfer resulted from prior training. Since differences among training device groups were not significant, it appeared that the fact of having had prior training was more important than was the nature of the specific device on which practice occurred. By the second block, the initial superiority of the 17-4 device disappeared although trainees from the 17-4M and the 17-B4 devices were still significantly faster than the untrained group. By the third block, the only difference was that the previously trained trainees as a whole were faster than the control group. After 40 trials the only remaining difference was the superior speed of 17-4M and 17-B4 trainees as a whole compared to control trainees.

In general, therefore, all three devices promoted positive transfer of training in terms of speed in applying BOT. After 50 trials, however, the performance of the control group had improved to the point where it was indistinguishable from that of the device groups.

Another way of looking at these same speed data was to examine the second set of simple effects. This analysis addressed the changes in speed for each group which occurred over the eight blocks of trials. The results indicated that trainees in the 17-4, 17-4M, and control groups significantly reduced their time between rounds as a function of practice. Trainees who had practiced on the 17-B4 device, however, showed no significant improvement in speed during transfer. Initially, they needed about

7.5 seconds to adjust fire, a speed not noticeably different from the approximately seven seconds they required at the end of transfer.

In summary, the training device groups exhibited initial positive transfer relative to an untrained control group. Positive transfer was pronounced, however, for only one of the two performance measures evaluated. The groups receiving prior training were able to adjust fire more rapidly than the baseline group, but this initial advantage gradually disappeared as the control group received more practice.

SUPPLEMENTARY ANALYSES

A potentially important aspect of device evaluation which is often ignored is user acceptance. In the present study, reactions to the training devices were solicited from both trainees and instructors. Subjective reaction scores were obtained by summing the 10 ratings given by each respondent on each of two occasions. Trainees rated their devices before and after transfer while instructors provided ratings before and after training.

The mean ratings from trainees following training and prior to transfer were 36.6, 36.9, and 41.7 for the 17-4, 17-4M and 17-B4 devices, respectively. An analysis of variance revealed a significant difference among these mean ratings ($F = 4.97$; $df = 2,51$; $p < .05$), with trainees on the 17-B4 rating that device higher than the other two. After transfer, however, there was no significant difference ($F < 1$; $df = 2,51$; $p > .1$). The 17-4, 17-4M, and 17-B4 received ratings of 38.5, 36.6, and 37.4, respectively.

Instructors' initial ratings were quite similar to the first reactions of trainees. The 17-B4 was rated highest (mean = 41.5), followed by the 17-4M (mean = 36.3), while the 17-4 received the lowest rating (mean = 30.5). The difference among ratings was significant ($F = 4.28$; $df = 2,9$; $p < .05$). After having trained students, however, the instructors were in closer agreement ($F < 1$; $df = 2,9$; $p > .1$). The 17-4 still received the lowest rating (mean = 31), but the 17-4M and 17-B4 devices switched positions. Reactions to the 17-4M improved to a mean of 38 while 17-B4 instructors viewed their device less favorably (mean = 35.5).

It should be noted that while trainees viewed the 17-4 and 17-4M in a very similar light, the instructors consistently gave the 17-4M a higher

rating. This difference in subjective reaction occurred in spite of the marked similarity between the two devices in terms of appearance and use.

Finally, by way of summarizing the results of the transfer portion of the study, data derived from one typical transfer-of-training equation are shown in Figure 5. These data were derived by expressing the performance data shown in Figures 3 and 4 in the equation:

$$\frac{E_i - C_i}{T - C} \quad \text{where}$$

$E_i$ = the performance of a training group at any time during transfer,

$C_i$ = the performance of the control group at that same point,

$T$ = asymptotic level of performance (set to 1.0 for accuracy and 5 seconds for speed), and

$C$ = initial level of performance of the control group.

Figure 5 reveals that the greater percent transfer occurred with respect to the speed with which BOT was applied rather than in terms of BOT accuracy. The relatively large amounts of initial transfer decreased as exposure to the criterion situation continued, so that by the fifth block of trials the untrained group was essentially as rapid as the trained groups.

Initially, however, for either accuracy or speed of performance, greater transfer was associated with the 17-4M and 17-B4 devices than with the 17-4. This ordering was mirrored in the overall subjective reactions of instructors who rated the 17-4M (37.15) and 17-B4 (38.5) over the 17-4 (30.75). Trainees' reactions did not reflect this difference; they judged the 17-4M (36.75) and 17-B4 (39.55) as comparable to the 17-4 (37.55).

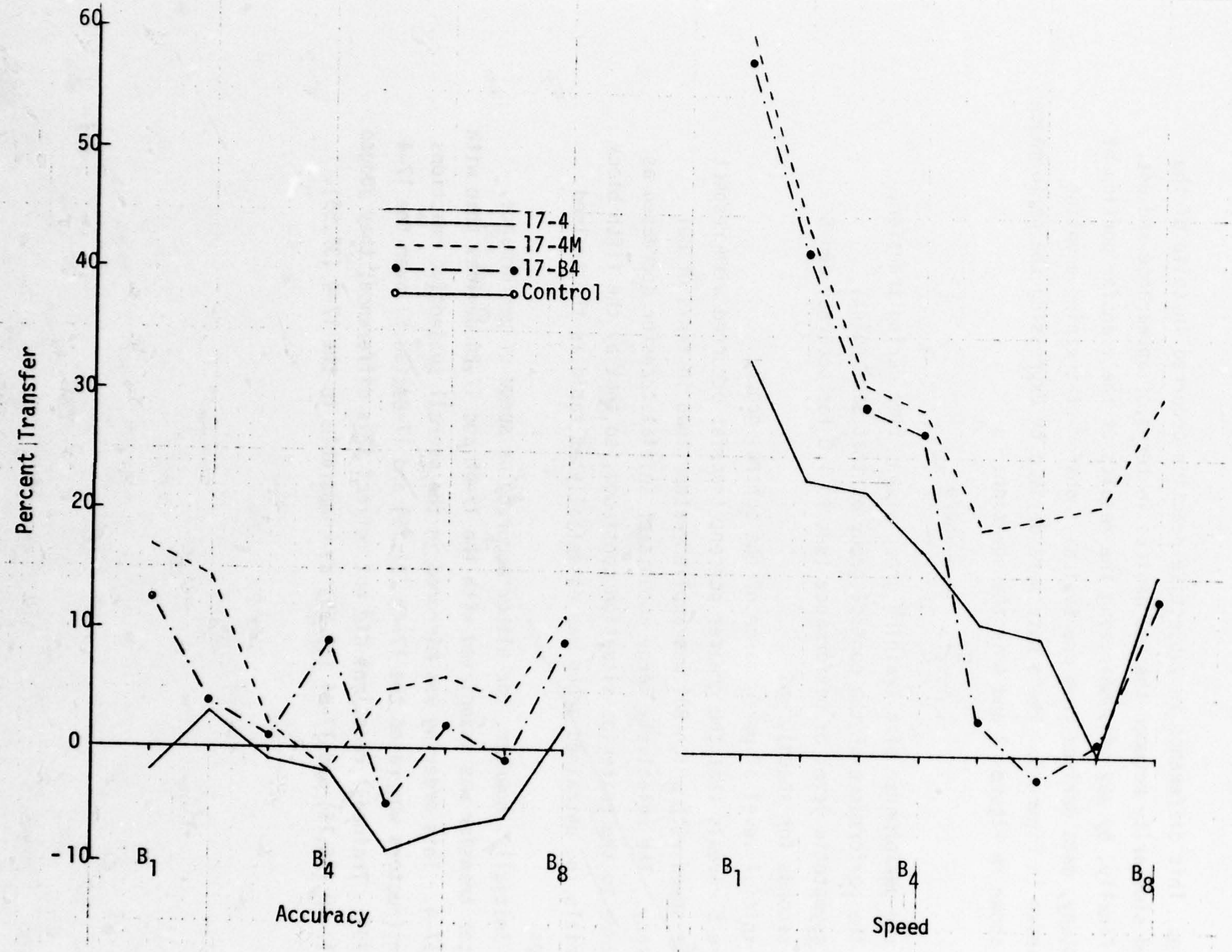


Figure 5. Percent transfer.

# DISCUSSION

In this section selected findings from the BOT study are discussed insofar as they may help clarify the relative effectiveness of the training devices, during both the acquisition and transfer phases of the experiment. Following these observations a summary evaluation of the three devices is provided, using the BOT task as the frame of reference.

Applying BOT is only one small aspect of the more general topic of tank gunnery. Therefore, the remainder of this section addresses some of the broader issues which must be considered when choosing devices for a gunnery training program. The points covered include: 1) the tasks comprising tank gunnery; 2) the tasks selected for training in AIT or the Armor School; and 3) the potential role which the 17-4, 17-B4, or 17-4M may have in support of this training.

## BURST-ON-TARGET STUDY

Acquisition. One of the most interesting outcomes of the BOT study is that trainees practicing on the 17-4M device required significantly more trials to reach criterion than did those who were assigned to the other two devices. This finding was not anticipated and complicates interpretation of the transfer of training results. The problem is that the relative superiority of the 17-4M trainees during transfer may simply be due to the fact that they received more practice in appling BOT. Consequently, it is important to consider alternative reasons for the difference in trials to criterion, as well as to speculate about the impact which such factors could have had on transfer.

Differences in the motivation, aptitude, or related skills of students who trained on the various devices could serve as one explanation for the larger number of trials required by the 17-4M group to reach criterion. It will be recalled, however, that trainees were matched across groups on a number of biographical and ability measures in an attempt to reduce the chances of such bias. Nevertheless, other variables which were not controlled for could have been associated with the 17-4M group, more so than with the other two groups. Even so, it is difficult to conceive of trainee variables which would serve, on the one hand, to retard acquisition and, on the other, to enhance transfer.

Alternatively, one might argue that the 17-4M device was inherently more difficult than the other two. There would seem to be little support for this notion, however. First, as previously shown in Figures 1 and 2, it is the 17-B4 which is clearly the most difficult device, at least initially. The low initial hit rate and long between-round times on the 17-B4 presumably stem from having to learn the operation of more complex controls, as well as from having to identify center of mass, trivial problems on the other devices. Second, in the opinion of most observers the 17-4M and the 17-4 were highly similar in appearance, method of operation, and consequently, in intrinsic difficulty. Initial hit rates on the two devices are fairly comparable as are the time-between-round intervals. This is true whether one references the Vincentized data or computes scores for the first 10 acquisition trials. Nevertheless, the rate of acquisition on the 17-4M was much slower than on the highly similar 17-4 device.

A third possibility is that the instructors may have been at least partially responsible for the greater amount of practice given on the 17-4M device. We have already seen that in spite of the similarities between the 17-4M and 17-4 devices, 17-4M instructors consistently rated their device higher. The higher ratings may be indicative of greater motivation or involvement on the part of this group of instructors. It would not be unreasonable to assume higher motivation in this group, especially compared to 17-4 instructors, inasmuch as the 17-4M was referred to throughout the study as the modified, newer, updated, or improved Green Hornet (17-4). Heightened motivation or even a competitive spirit could have manifested itself in a number of ways which would have resulted in trainees requiring more trials to reach criterion.

For example, being more motivated, 17-4M instructors were perhaps inclined to apply the hit/miss criterion more rigorously. In an attempt to get the most training benefit out of their device they might have treated near misses as misses, behavior which would effectively provide trainees with additional practice in applying BOT. Secondly, if these instructors were more involved, then they might adhere more closely to their instructions; specifically, they might emphasize both accuracy <u>and</u> speed in applying BOT. The speed data in Figure 2 support this interpretation. Thus, the

increasing times of the 17-B4 group later in training suggest that trainees were sacrificing speed in order to maximize the probability of hits. Conversely, the much slower rate of improvement in accuracy for the 17-4M group was accompanied by short between-round intervals throughout practice. The 17-4 group had a relatively fast rate of improvement in accuracy, but this was accompanied by a slower speed than that reached by the 17-4M group.

The point to be drawn from their discussion is that several factors in addition to the device itself can determine what skill is acquired, how rapidly acquisition takes place, and what degree of transfer results. In the present study instructors appear to have played a central role in determining the rate of acquisition as well as the nature of the specific skills which were acquired.

Transfer. From the preceding discussion, one needs to consider the extent to which results of the transfer portion of the study reflect the effectiveness of the training devices per se. Specifically of interest is whether the amount of transfer displayed by the 17-4M trainees is primarily a function of the greater amount of practice experienced by that group.

Amount of practice per se does not appear to account for the relative ordering of groups, either for accuracy or speed. The basis for this impression stems from a series of correlations which were computed between trials-to-criterion scores and various transfer measures. For example, within the 17-4 group the correlation of trials-to-criterion with speed upon initial transfer was $r = .42$. While this relationship is significant, it is in the wrong direction. That is, if additional practice is beneficial during transfer, then longer trials to criterion should be associated with shorter times, producing negative correlations. Analogous correlations for the 17-4M and 17-B4 groups were $r = -.27$ and $r = .21$, neither of which was significant. Combining groups, the correlation was $r = .00$. Similar, essentially zero, correlations were obtained within and across groups for accuracy measures. Consequently, one cannot argue statistically that the relative ordering of the device groups is due to differential amounts

of practice per se.

Rather, some differential treatment causing improved transfer incidentally resulted in more trials to criterion. One possible hypothesis is that the trainees in the 17-4M group were operating under a speed "set" established early in acquisition (i.e., they applied BOT as rapidly as possible throughout training and gradually acquired accuracy). In effect, trainees first learned to apply BOT rapidly, then gradually acquired accuracy. While this "set" would lead to more trials before a criterion of accuracy was reached, there is no implication that the longer one practices, the faster he gets. Furthermore, it could be hypothesized that upon transfer these trainees maintained their speed set; however, since they had acquired the skills necessary for accuracy, the net result for transfer would be short between-round intervals without consequent loss of accuracy.

The hypothesis of differential speed/accuracy sets is also supported by the speed data presented in Figure 4. The 17-4M trainees are considerably faster than the 17-4 group, and on a par with the 17-B4 trainees. The former finding is obtained in spite of the fact that the 17-4 and 17-4M are such highly similar devices. The latter result is obtained in spite of the assumption that practice on controls physically similar (17-B4) to those of the tank should have offered an advantage, at least initially, over the 17-4M, which had dissimilar controls. While these speculations are interesting, it should be remembered that while all three device groups were initially superior to the untrained control group, no significant differences were found among the device groups.

A final interesting outcome from analysis of the speed data was the apparent lack of improvement demonstrated by the 17-B4 trainees. Reasons for this finding are at best speculative. One possibility is that trainees in this group simply did not attempt to apply BOT "as rapidly as possible," although instructions to that effect were given in both the training and transfer settings. Instead, they may have settled upon a comfortable speed and concentrated on improving their accuracy. Additional data bearing on this notion came from an ancillary study, in which highly practiced (320 practice trials) control students were given 80 transfer trials on

the 17-B4. Upon transfer, their initial speed was 9.5 seconds, equivalent to the best performance exhibited by the 17-B4 group throughout their entire acquisition phase. By the last block of transfer trials control trainees had decreased their time to approximately seven seconds. Presumably their superior speed on the 17-B4 was due in large measure to either their prior extensive practice in applying BOT, or to the 17-B4 trainees' accuracy set.

Device Evaluation. All things considered, the three devices employed in the BOT transfer of training study were quite similar in effectiveness. If one were forced to differentiate among them, a very slight edge would have to be given to the 17-4M and 17-B4 devices relative to the 17-4. In no case, however, were the devices significantly different from one another. As shown in Figure 5, in terms of a commonly used measure of transfer of training, the 17-4M and the 17-B4 exhibit a modest amount of transfer for the accuracy measure, while all three devices show a more pronounced benefit in terms of speed of applying BOT.

In operation the 17-4 seemed generally reliable, the only real malfunction possibly being failure of the "burst" light bulb. Although basically a very simple device, the 17-4 does include the controls and displays needed to perform BOT, and it can be used to involve several trainees at a time. Its major drawback is the weight and/or friction which must be overcome when laying the cross hairs on a designated target. Precise positioning is very difficult and muscular fatigue becomes a real problem during even brief periods of training. Other less serious deficiencies are the lack of realistic target scenes, the absence of tracking controls, awkward placement of the instructor, and a "sight" which makes changing of reticles time-consuming and affords no exposure to M32 sighting problems. In spite of these deficiencies, the device seems appropriate for providing trainees with experience in the principles and procedures involved in BOT adjustment of fire. Instructor acceptance of the device would be enhanced were the weight/friction problem resolved, as it apparently had been in the old version of the 17-4 described in DA Pamphlet 310-12 (1972).

The operation of the 17-4M device is highly similar to that of the 17-4 and consequently many of the comments made about the 17-4 apply here as well. The major advantage of this modified version of the older Green Hornet is a marked reduction in friction achieved by using lighter materials and nylon bearings. Positioning is more precise and fatigue is less of a factor. Getting the instructor around in front by supplying him with an extension cord for the firing switch is beneficial. In both this device and the 17-4 the instructor's ability to prolong the burst would seem useful, especially early in training. The scene is still unrealistic and is painted on thin sheets of material which are prone to tearing. The scroll approach to mounting the target scene is not beneficial and is a feature which would probably not be taken advantage of in actual use. To the extent that the rollers slip, the scene does not lie tightly against the rear plate. This in turn causes the "burst," when it is presented, to appear diffuse and unfocused, a situation which is not at all conducive to accurate adjustment of fire. Again, however, this device appears to serve the purpose for which it is intended--introducing students to the principles and procedures involved in applying BOT.

The 17-B4 is a much more sophisticated device and is subject to a greater variety of potential malfunctions. During the course of the study a recurrent problem on some of these devices was a decrease in the intensity of the laser burst, especially on the repeater display which the instructors monitored for scoring purposes.

The advantage of this device over the others lies in the use of more realistic target scenes (i.e., slides) which are viewed through an M32 sight. The target slides can be used to depict a variety of target vehicles, aspects, ranges, etc.; this makes possible an emphasis on target identification as well as determination of the center of vulnerability. The deficiencies are two-fold. The first and much more serious shortcoming is a control system which makes it exceedingly difficult to lay the cross hairs precisely and rapidly. Instead of being able to "zero-in" readily on the target without changing directions, the dynamics of the control system force one to adopt a successive approximation approach. This would be acceptable were it not for the fact that one constantly

seems to be overcorrecting when trying to make a precise lay. The fact that the dynamics differ from those in the tank does not seem to represent a serious deficiency; rather, the problem is that positioning of the cross hairs is overly difficult. A far less serious drawback, which is effectively overcome through use of the repeater-button, is the short duration of the burst. A longer burst would presumably be beneficial early in training. Overall, this device would be effective in teaching the principles and procedures of BOT. Both trainees and instructors react favorably toward it.

The real issue in evaluating these or any other devices lies in defining the training objective, both in terms of content and the level of proficiency required. For the moment we are concerned with the relative effectiveness of the three devices in teaching trainees to apply BOT adjustment of fire with static targets. The transfer situation is either the M55 or the 3A102B. Interviews with AIT and Armor School training personnel suggest that a fairly low skill level is acceptable. The emphasis seems to be on insuring that trainees know how to apply BOT, and not on demonstration of a high level of proficiency in doing so. Given this objective, let us reassess the effectiveness of the three devices.

The 17-4 and 17-4M would provide trainees with the kind and amount of training which is required. Use of either would be relatively efficient since several trainees could be familiarized simultaneously, while one trainee actually applied BOT. Use of the 17-B4 for this same purpose would seem unwarranted. The 17-B4 is clearly far more sophisticated than is ncessary in this context. Finally, one could question the benefit to be gained from using any of the three devices. Why not have trainees practice BOT directly on the M55 or 3A102B? Use of these latter devices for initial training would seem unwise for three reasons. First, it has been shown that prior exposure to the other devices does improve performance during transfer. Second, the instructor in the M60A1/3A102B or M55 is not in a position to interact readily with trainees, rendering cueing, prompting, or critiquing less effective. Third, other trainees cannot participate while one individual practices. Consequently, the efficiency with which

trainees can acquire familiarity with BOT is substantially reduced.

Exposure to either the M55 or 3A102B is of course desirable and skill on these devices currently represents a training objective. Greater benefit from such exposure might result, however, were the following steps taken. First, primarily in the M60A1/3A102B context, greater care needs to be exercised in mounting and focusing the laser. Either a diffuse pulse or movement of the laser within its mount will largely negate the value in firing. Second, the value can be increased by making the task more demanding. In applying BOT on static targets this can be readily accomplished by reducing target size, as was done in the present study. The eight-inch targets which are often used represent targets which are 13 feet square at a distance of 1200 meters. In essence, the larger targets may not impress upon trainees the need for precision in the initial lay and in the subsequent adjustment of the aiming point.

## TANK GUNNERY

The evaluation provided above is focused on only one aspect of tank gunnery. In fact, there are several other tasks which the gunner performs, more or less frequently, when dealing with the main gun. Task-analytic data provided by the Task Analysis Division of the Director of Training at Fort Knox reveal that tasks involving the main gun primarily fall in Category 20--Tracked Vehicles. Those which are performed by 11E MOS personnel include at least the following kinds of activities:

Task 301--Prepare a range card for tracked combat vehicle.
Task 302--Issue a fire command for a tank.
Task 304--Acquire ground targets for tracked combat vehicle.
Task 320--Boresight main gun on M60/M60A1 tank.
Task 324--Zero main gun on M60/M60A1 tank.
Task 329--Load 105 mm main gun (M60/M60A1).
Task 334--Fire M60/M60A1 main gun.
Task 338--Apply immediate action in case of M60/M60A1 main gun failure to fire.
Task 342--Unload misfired gun round on an M60/M60A1 tank.
Task 354--Disassemble/assemble breech mechanism on an M60/M60A1 tank.

Given these inputs, cognizant personnel from the 1st Training Brigade and from the Armor School were interviewed in an attempt to establish: 1) which of the above kinds of tasks were covered during training; and 2) how training was accomplished. The purpose in obtaining such information

was to broaden the basis for evaluation of the 17-4, 17-4M, and 17-B4 devices. When a task was identified where one of the training devices was (or could be) employed, the potential usefulness of the other devices in providing the same training was examined. The results of these considerations are summarized below for both the AIT and Armor School settings.

In either AIT or AOB/NCOB there are a fairly limited number of tasks and component subtasks which are germane to the kinds of devices examined in the present report. The first of these is Task 302 (Issue a Fire Command for a Tank) which involves the following relevant subtasks:

001 Initial fire command,
002 Repeat or correct elements of initial command,
003 Subsequent for M60, M60A1, M48A1.

In AIT these subtasks are addressed primarily in the classroom and are touched upon in the course of other exercises conducted on the 17-B4. In the Armor School training on this task and similar tasks for the M60A2 and M551 is conducted in the classroom and on the 17-B4. In both settings the 17-4 or 17-4M could be employed just as readily.

In the Armor School, subtask 320-010 (Set Tank Battle Lights) is practiced in a variety of settings including the 17-B4. Since this subtask is primarily procedural and straightforward, it could be covered just as readily on the other two devices.

In both locations most extensive use of Burst-on-Target or Conduct-of-Fire trainers occurs in conjunction with Task 334 (Fire M60/M60A1 Main Gun). The subtasks which are relevant include:

005 Select main gun ammunition,
010 Fire from gunner position,
011 Fire from gunner position (telescope),
012 Adjust fire (BOT),
013 Adjust fire (alternate method telescope),
014 Adjust fire (alternate method periscope).

These subtasks are the bulk of what is covered in AIT in such classes as: Direct Fire, Primary Sight (G-8); Direct Fire, Secondary Sight (G-9); Direct Fire, Daylight I (G-10); and Direct Fire, Daylight II (G-11). Comparable periods of instruction in the Armor School include Conduct of Fire and Target Engagement. In all of these sessions trainees are introduced to the various topics in the classroom and then given practical instruction

on the 17-B4 device. (See Appendix E for predictions of device effectiveness.)

There again, however, the 17-4 or the 17-4M could be employed without any obvious loss in effectiveness. All three devices permit several trainees to act as various members of the tank crew. Similarly, each device permits trainees to activate the appropriate switches prior to firing, to select ammunition, and to practice firing and adjustment-of-fire procedures. All three can even permit trainees to practice Task 334 assuming a moving target (although targets are static).

As the devices are presently configured, there are three respects in which the 17-B4 would appear to be more effective, or at least more convenient to use. First, the availability of more realistic targets gives trainees practice in applying fire against targets viewed in the front, flank, or oblique perspective. The ability to determine the center of vulnerability, given different aspects of the target, is stressed in AIT, for instance. The variety of slides available on the 17-B4 makes practice of this skill possible. The 17-4 and 17-4M would also be effective in providing such training were targets painted on the display scenes to represent the different aspects. This improvement could be easily made.

Second, a significant portion of Task 334 requires trainees to fire the main gun using the telescope and a reticle appropriate to the kind of ammunition which has been indexed. When the 17-B4 is used to provide practice in these areas, different reticles can be selected and displayed instantaneously. The 17-4 and 17-4M come equipped with a variety of overlays representing the different reticles. Their changing and remounting is awkward and time-consuming, however. Improvement in this area, though, seems straightforward and would contribute to increased effectiveness.

Third, the 17-B4 library of enemy targets permits incidental practice in target detection, location, and especially identification. These skills are not presently stressed in AIT but they are practiced in the Armor School. The 17-4 or 17-4M does not provide for this kind of training as the devices are presently configured. Were such training required, an alternative to use of the 17-B4 would be to conduct it in a classroom, using suitable slides.

In summary, all three devices seem to possess the potential for familiarizing students with the procedures involved in effectively firing the main gun under the variety of conditions typically encountered. A possible training strategy might call for the following sequential progression through these devices. Basic procedures could be practiced on a relatively simple and inexpensive modification of the 17-4 or 17-4M device. To maximize use of the 17-B4 devices currently on hand, students could progress to a practicum on target engagement similar to that offered in the Armor School. During such a session, trainees would use the 17-B4 to integrate their skills, specifically those involving target identification, initial lay on the center of vulnerability, and appropriate adjustment of fire. This session would be followed by subcaliber exercises conducted on the laser range. During these exercises students would transfer their knowledge and skills to the operational vehicle, and would acquire basic skill in conduct of fire using the M60/M60A1 controls.

SUMMARY

This report describes an experiment which is part of a larger effort with the objective of developing and evaluating a model which can be used to predict the effectiveness of training devices. The experiment reported here compares the effectiveness of three Burst-On-Target (BOT) training devices for preparing Advanced Individual Training (AIT) personnel to apply BOT techniques with the 3A102B laser device mounted in the M60A1 tank. The three devices were: (1) the 17-4 BOT trainer (the "Green Hornet"), (2) a modified version of the 17-4 trainer which was fabricated specifically for this experiment by the Training Aids Department at Fort Knox, and (3) the 17-B4 Conduct-of-Fire Trainer.

Three groups of 20 trainees each were trained on the devices until they achieved a proficiency criterion of 90% hits on the second shot of a BOT series, or until they had received 320 trials. All trainees reached proficiency within the 320 trial period. A fourth group of 20 trainees practiced for 320 trials on the M3A102B device. This group served as the control group. During training, data were collected on both time (between first and second shots of a BOT engagement) and accuracy measures. Following training, the three experimental groups were transferred to the 3A102B devices where each trainee received 80 BOT trials. Time and accuracy data were recorded. In addition, device acceptance data were obtained from both trainees and instructors.

Results from the acquisition phase indicated the following:

1. The number of trials required to reach the 90% criterion were 125.0 for the 17-4 (range 40-209); 169.4 for the 17-4M (range 32-309); and 134.1 for the 17-B4 (range 25-226). The differences in mean number of trials was statistically significant.

2. Accuracy data for the three training groups and the control group indicated increasing proficiency as a function of practice. However, initial percentage hits on the 17-B4 was below that of the other devices. Time data indicated that the 17-B4 group also took longer between shots than the other two devices groups. The

control group acquisition was not different from that of the 17-4 and 17-4M groups.

Results from the transfer phase indicated the following:

1. Trainee accuracy and time between rounds was significantly affected by the tank on which they shot and this influence varied over time. Subsequent analyses were adjusted to remove this bias.

2. Accuracy data revealed no significant differences among the four groups. Trainees initially performed at a 42% hit rate and gradually improved to approximately 60% hits. Further, a priori analyses were performed and are reported in the Discussion.

3. Prior training did have a substantial impact on the time between rounds. A significant interaction between groups and blocks of trials implies that differences among groups changed over time. The initial wide spread in performance decreased as practice continued.

4. In general, all three devices promoted positive transfer of training in terms of speed in applying BOT. After 50 trials, however, the performance of the control group had improved to the point where it was indistinguishable from that of the device groups.

5. Time between rounds data indicated that the trainees in the 17-4 and 17-4M groups significantly reduced their time between rounds as a function of practice. Trainees who practiced on the 17-B4 device, however, showed no significant improvement in speed during transfer.

Acceptance data from trainees before transfer and after training indicated a significant difference in preferences among the three devices. After training, however, these differences had disappeared. Instructors' initial ratings of the three devices were quite similar to those of trainees. After training there were no differences. Instructors consistently rated the 17-4M better than the other two devices.

The three devices seem effective for initial BOT training, and may have potential effectiveness for training other tasks in tank gunnery.

## REFERENCES


Department of the Army Pamphlet 310-12. Index and description of Army training devices. October 1972.

Hays, W. L. Statistics. New York: Holt, Rinehart and Winston, Inc., 1963.

Kirk, R. E. Experimental Design: Procedures for the Behavioral Sciences. Belmont, California: Brooks/Cole, 1969.

Wheaton, G. R., Fingerman, P. W., Rose, A. M., and Leonard, R. L., Jr. Evaluation of the effectiveness of training devices: Elaboration and application of the predictive model. ARI Research Memorandum 76-16, 1976.

Wheaton, G. R., Rose, A. M., Fingerman, P. W., Korotkin, A. L., and Holding, D. H. Evaluation of the effectiveness of training devices: Literature review and preliminary model. ARI Research Memorandum 76-6. April 1976.

Wheaton, G. R., Rose, A. M., Fingerman, P. W., Korotkin, A. L., and Holding, D. H. Evaluation of the effectiveness of training devices: II. Literature review and preliminary model. Second Interim Report. U.S. Army Research Institute Contract No. DAHC 19-73-0049. Washington, D.C.: American Institutes for Research, 1974.

## APPENDIXES

APPENDIX A

## Preexperiment Briefing for Instructors

Good afternoon, I am ____________________ and this is ______________ (coordinator). Please feel free to interrupt if you have any questions. As has been explained, there are four groups involved in this experiment, each trained on a different device. The four of you will be responsible for training 20 trainees in the primary method of adjustment of direct fire, BOT, on the ________device. The trainees you will be training will have received their classroom instruction in BOT, but will have had no practical exercises in BOT on this or any other training device.

You are the experts in training tank gunnery, and will be pretty much free to train in the way you are accustomed. The few things I will ask you specifically to do are designed to assure the validity of the experiment, to guarantee comparability between the four groups. Remember, we are not evaluating your training technique. Rather, each group's performance will be used to enable us to evaluate the training devices. You can help us by bringing each trainee to a high performance level as rapidly as possible. We will do this within the ground rules which I will describe to you.

Please examine Handout No. 1, the training schedule. On Wednesday morning at 0730 hours, five trainees will report to each of you. You will have a half hour to brief them on the training device and BOT. You may use this half hour as you think best with one exception: no trainee is to actually operate the device, to fire a shot, or manipulate the controls himself, during this briefing period. Following this period, each man will have a twenty-minute session on the device itself, while the other 4 trainees observe. One of these will serve as the Loader. After one trainee has finished firing, there will be a short, four-minute break, and then the next man will take a twenty-minute practice session. After all five men have had one session, at approximately 0950, there will be a fifteen-minute break. We will continue in this fashion following the schedule, repeating it on Thursday. Test coordinators will insure that trainees always practice in the same order.

During each 20-minute session, a trainee will fire 40 BOT trials. A trial consists of a fire command from you, a shot by the trainee, a BOT adjustment by the trainee, and a second shot. Thus all trials will consist of two shots, a first round, and a BOT round. Please examine the sample score sheet. At the top is room for the trainee's name and your name, the date, the time of the session, the device, the trainee's Social Security number, and the score for the session. This information, except for the score, should be filled in for each session during the short, four-minute breaks interspersed between each session. At the end of each session, the coordinator or myself will collect the sheets and we will fill in the score. Notice the second column, labeled "Trial Number." There are 40 lines on each score sheet, one for each trial in the session. To the right of the trial numbers are "hit" and "miss" columns. For each trial, we want you to check whether the trainee hit or missed the target on his second shot; that is, his BOT round. To the right of these columns is a column for recording an elapsed time measure for each trial. The time we want is the time from the trainee's first shot to his second shot. Thus, you will start timing when he fires the first round on each trial and stop when he fires his second round. The column to the left of "Trial Number" is labeled First Shot-target/error.

M55 — This is the range error you will introduce on the trial, so that the trainee will miss with his first round and be forced to adjust.

17-4, 17-4 Mod. — On the plate on the back of the device you will find eight holes with labels corresponding to these designations. This column indicates the error you will introduce on each trial so that the trainee will miss with his first round and be forced to adjust.

17-B4 — You may ignore this column, since it represents range errors to be introduced on other devices. You will press the "Random" button before each trial to introduce some error, so that the trainee will miss with his first round and be forced to adjust.

On the far left, you will notice that the trials are grouped into blocks of eight trials, labeled by the letters A thru E. The trainees will shoot at five different targets, corresponding to these letters (depending

on the device). The first eight trials will be fired at target A, the next eight at B, and so on. You might make a note on the sheet that I have designated ________as target A, . . ..

Are there any questions so far?

Now take a look at the second handout, which describes the sequence of events for a single trial. All trials will begin with the turret power and main gun power on. These controls and the ammunition indexing handle will not be used. At the beginning of each trial, you will enter the error [as designated on the score sheet by pressing "random" (17-B4)] for that trial. You will then give a fire command which indicates the target as designated on the score sheet. The Loader will operate the "Safety/Fire" switch and say "Up." When the trainee fires his first shot, you will start your stopwatch. When he fires his second shot, you will stop the watch and score his second shot. Then, announce "hit" or "miss" to the trainee, and record it on the score sheet along with the elapsed shot-to-shot time on the appropriate line. Prepare for the next trial by zeroing the stop watch, and entering the error for the next trial into the device. Give the fire command for the appropriate target and so on. Between trials you may critique as you feel is appropriate. In particular, notice whether the trainee acquires the correct sight picture for his first round. This is important since it assures that each trainee starts adjusting from the same point. Remember that to stay on schedule we have to get 2 trials off per minute, which may be a little tight at first. We understand that you might have to extend into the breaks, especially for the first few sessions. We will try this whole procedure in a couple of minutes, but do you have any questions to this point?

Spotters for M55?

Okay. Another item concerns the scoring. I mentioned that we will pick up the sheet after each session and score it.

Not M55 Group

We will be monitoring to determine when each trainee reaches a high level of second round hit proficiency. When this happens, the trainee will be removed from your group, and will receive no further training until Friday when he transfers to the M55 device.

Finally, we have adopted a very stringent hit criterion. Each target has a small area designated as the center of vulnerability. A hit will be scored only if the second round burst hits this designated area. Be sure to show the trainee the exact target area by placing the reticle yourself before allowing the trainee to fire at a new target.

M55 only

A hit on this point will show up when no return from the laser can be spotted, since the point is made of a non-reflective material. Your spotter will be able to assist you in making hit and miss judgments; however, you will have the primary say, and the spotter will act as a backup.

If there are no questions, let's practice a little.

Be sure and demonstrate how to operate stop watches, including how to wind them. Make sure each TC runs another TC thru several trials until he has the procedure down well.

On the 17-B4 make sure laser is recharged.

Handout 2--Trial Procedure

1. Set error for first shot.
2. Fire command (with appropriate target).
3. Start timing when first round is fired.
4. Stop timing when second round is fired.
5. Score second round as hit or miss and give trainee feedback.
6. Record hit or miss and elapsed time on score sheet.
7. Critique as necessary.
8. Zero stopwatch.
9. Go to #1 for next trial.

## APPENDIX B

Trainee______________________Instructor________________

Date____________Time___________Social Security #______________

Device______________Score________________

| First Shot Target/Error | Trial Number | Hit | Miss | Elapsed Time |
|---|---|---|---|---|
| 2000 | 1 | : | | |
| 1800 | 2 | : | | |
| 1400 | 3 | : | | |
| 1000 | 4 | : | | |
| 1400 | 5 | : | | |
| 1800 | 6 | : | | |
| 2000 | 7 | : | | |
| 1000 | 8 | : | | |
| 1000 | 9 | : | | |
| 2000 | 10 | : | | |
| 1800 | 11 | : | | |
| 1400 | 12 | : | | |
| 1000 | 13 | : | | |
| 1400 | 14 | : | | |
| 1800 | 15 | : | | |
| 2000 | 16 | : | | |
| 2000 | 17 | : | | |
| 1800 | 18 | : | | |
| 1400 | 19 | : | | |
| 1000 | 20 | : | | |
| 1400 | 21 | : | | |
| 1800 | 22 | : | | |
| 2000 | 23 | : | | |
| 1000 | 24 | : | | |
| 1000 | 25 | : | | |
| 2000 | 26 | : | | |
| 1800 | 27 | : | | |
| 1400 | 28 | : | | |
| 1000 | 29 | : | | |
| 1400 | 30 | : | | |
| 1800 | 31 | : | | |
| 2000 | 32 | : | | |
| 2000 | 33 | : | | |
| 1800 | 34 | : | | |
| 1400 | 35 | : | | |
| 1000 | 36 | : | | |
| 1400 | 37 | : | | |
| 1800 | 38 | : | | |
| 2000 | 39 | : | | |
| 1000 | 40 | : | | |

APPENDIX C

NAME ____________________

RANK ____________________

SS # ____________________

## DEVICE REPORT FORM

### Instructions

The benefit that the Army can get from using any training device depends on its acceptance by the people who must use it (both instructors and trainees) as much, if not more, than it depends on how well the device resembles the actual field situation. For this reason, we are interested in finding out how well you liked working with the device you worked with during the course of our study.

Below you will find a number of statements about the device. For each statement we would like to know how much you agree or disagree with it. After each statement you will find five boxes labeled: 1. Strongly Disagree. 2. Disagree. 3. Neither Agree nor Disagree. 4. Agree. 5. Strongly Agree. Choose the box that best describes how you feel about the statement on the left and put an X in that box. Do the same for each of the statements. Thank you.

| | Strongly Disagree | Disagree | Neither Agree Or Disagree | Agree | Strongly Agree |
|---|---|---|---|---|---|
| 1. Using this device is a good way to train personel for this task. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 2. This device is extremely boring to use. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 3. The device is so realistic that it is almost like being in the real situation. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4. Instructors have a tough job to train people using this device. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 5. This device is better than most other methods the Army has for training people in this task. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 6. The device may be good but I don't like to use it. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 7. I feel that I really learned something about tank gunnery while using this device. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 8. If I had a choice, I would rather train by some other method than by using this device. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 9. It is clear that the Army was careful to get the opinion of instructors and other experts when they planned the development of this device. | ☐ | ☐ | ☐ | ☐ | ☐ |
| 10. The device training will be of little help when one has to apply his training in a field setting. | ☐ | ☐ | ☐ | ☐ | ☐ |

APPENDIX D ANALYSIS OF VARIANCE TABLES

Table D-1

ANOVA OF ACCURACY EFFECTS

| Source | Sum of Squares | Degrees of Freedom | Mean Square | F |
|---|---|---|---|---|
| Mean | 1611.389 | 1 | 1611.389 | |
| G(Groups) | 3.546389 | 3 | 1.182129 | 0.9673 |
| B(Blocks) | 18.98495 | 7 | 2.712136 | 10.4333* |
| R(Rounds) | 24.14914 | 9 | 2.683237 | 13.4889* |
| T(G) (Trainees) | 83.10612 | 68 | 1.222149 | |
| GB | 2.545486 | 21 | .1212136 | 0.4663 |
| GR | 3.240952 | 27 | .1200352 | 0.6034 |
| BR | 33.75609 | 63 | .5358109 | 2.7204* |
| TB(G) | 123.7364 | 476 | .2599504 | |
| TR(G) | 121.7404 | 612 | .1989222 | |
| GBR | 35.55225 | 189 | .1881071 | 0.9551 |
| TBR(G) | 843.7773 | 4284 | .1969602 | |

*p<.001

Table D-2

ANOVA OF TIME BETWEEN ROUNDS EFFECTS

| Source | Sum of Squares | Degrees of Freedom | Mean Square | F |
|---|---|---|---|---|
| Mean | 312522.1 | 1 | 312522.1 | |
| G(Groups) | 2653.162 | 3 | 884.3875 | 5.6650** |
| B(Blocks) | 2395.808 | 7 | 342.2583 | 15.6867* |
| R(Rounds) | 277.1350 | 9 | 30.79277 | 4.6633* |
| T(G) (Trainees) | 10615.76 | 68 | 156.1141 | |
| GB | 1174.311 | 21 | 55.91956 | 2.5630* |
| GR | 180.3418 | 27 | 6.679325 | 1.0115 |
| BR | 1223.545 | 63 | 19.42134 | 2.9307* |
| TB(G) | 10385.57 | 476 | 21.81841 | |
| TR(G) | 4041.186 | 612 | 6.603244 | |
| GBR | 1031.292 | 189 | 5.456573 | 0.8234 |
| TBR(G) | 28389.20 | 4284 | 6.626798 | |

*p<.001

**p<.005

Table D-3

ANOVA OF SIMPLE EFFECTS
(from Kirk, 1969)

| Source | Sum of Squares | Degrees of Freedom | Mean Square | F |
|---|---|---|---|---|
| Devices at Block 1 | 1469.691 | 3 | 489.897 | 12.69* |
| Devices at Block 2 | 819.308 | 3 | 273.103 | 7.07* |
| Devices at Block 3 | 372.489 | 3 | 124.163 | 3.22** |
| Devices at Block 4 | 340.467 | 3 | 113.489 | 2.94*** |
| Devices at Block 5 | 139.946 | 3 | 46.649 | 1.21 |
| Devices at Block 6 | 198.388 | 3 | 66.129 | 1.71 |
| Devices at Block 7 | 207.780 | 3 | 69.260 | 1.79 |
| Devices at Block 8 | 279.272 | 3 | 93.091 | 2.41 |
| Pooled Error | 21001.33 | 544 | 38.605 | |
| | | | | |
| Blocks at Device 1 | 797.99 | 7 | 113.999 | 5.22* |
| Blocks at Device 2 | 441.349 | 7 | 63.050 | 2.89**** |
| Blocks at Device 3 | 108.624 | 7 | 15.518 | .71 |
| Blocks at Control | 2220.885 | 7 | 317.269 | 14.54* |
| Error (SBxG) | 10385.57 | 476 | 21.818 | |

*$p < .0005$

**$p < .025$

***$p < .05$

****$p < .01$

APPENDIX E PREDICTIONS OF DEVICE EFFECTIVENESS

The three training devices were evaluated in terms of predicted effectiveness following procedures described in detail elsewhere (Wheaton, Fingerman, Rose, & Leonard, 1976). The predicted effectiveness of each device was determined for five of the subtasks comprising Task 334 (Fire M60/M60A1 Main Gun). The subtasks included:

334-10 Fire from the gunner's position

334-11 Fire from the gunner's position using the telescope

334-12 Adjust fire by means of BOT

334-13 Adjust fire using the alternate method and telescope

334-14 Adjust fire using the alternate method and periscope

Estimates of training effectiveness ($\tau$) are provided in the following table. Summary data are presented for each device on each subtask. The various columns of data are defined as follows:

C = subtask element communality estimate

S = mean (physical and functional) similarity estimate

WLD = weighted learning difficulty score

TTA = training technique analysis score

$\Sigma$ = the sum of the products of C x S x WLD x TTA for each subtask element

LD = the sum of WLD for each subtask element

$\tau = \Sigma/LD$

Values of $\tau$ range between zero and 1. The larger values represent greater predicted effectiveness.